ON THE SUPPORT OF MULTIMEDIA APPLICATIONS OVER WIRELESS MESH NETWORKS

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ABSTRACT

For next generation wireless networks, supporting quality of service (QoS) in multimedia application like video, streaming and voice over IP is a necessary and critical requirement. Wireless Mesh Networking is envisioned as a solution for next networks generation and a promising technology for supporting multimedia application.
With decreasing the numbers of mesh clients, QoS will increase automatically. Several research are focused to improve QoS in Wireless Mesh networks (WMNs), they try to improve a basics algorithm, like routing protocols or one of example of canal access, but in moments it no sufficient to ensure a robust solution to transport multimedia application over WMNs.
In this paper we propose an efficient routing algorithm for multimedia transmission in the mesh network and an approach of QoS in the MAC layer for facilitated transport video over the network studied.

Keywords

Wireless mesh network, QoS, routing protocols, CBRP, CSMA/CA, 802.11e.

1. INTRODUCTION

In recent years, Wireless Mesh Networks (WMNs) attract considerable attentions due to their various potential applications, such as broadband home networking, community and neighbourhood networks, and enterprise networking. Many cities and wireless companies around the world have already deployed mesh networks. Urgently events like emergency or military forces in war for example are now using WMNs to connect their computer in field operations as well. For this application, WMNs can enable troops to know the locations and status of every soldiers or doctors, and to coordinate their activities without much direction from central command. [1]

MWNs have also been used as the last mile solution for extending the Internet connectivity for mobile nodes. For example, in the one laptop per child program, the laptops use WMNs to enable students to exchange files and get on the Internet even though they lack wired or cell phone or other physical connections in their area [2].

A wireless mesh network (WMN), as depicted in Fig. 1, consists of a number of wireless stations (nodes) that cover an area. The nodes communicate with each other in a multi-hop via the wireless links [3].

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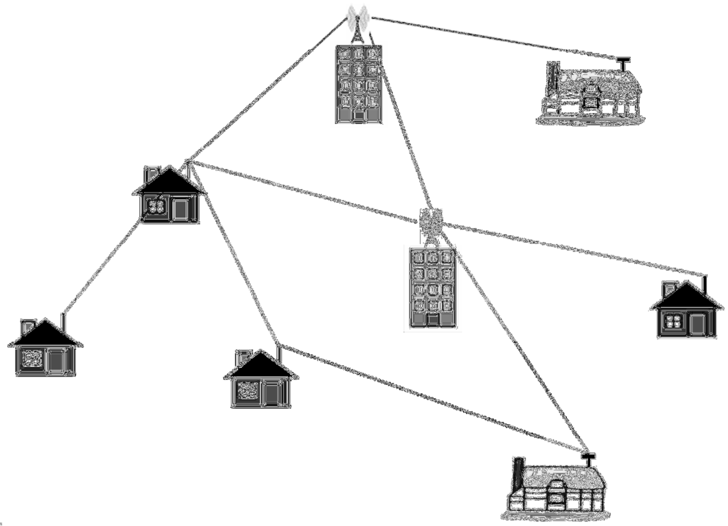

Figure 1. A generic wireless mesh network

In our work, we propose an efficient routing protocol to transport multimedia traffic in wireless mesh network and we improve MAC layer to support a real time application on WMN.

Before proposing our model, we introduce definitions of routing protocols available on the WMN and standard MAC layer to support QoS.

2. ROUTING PROTOCOLS

Generally, we can found two main types of routing protocols for wireless networks: (i) protocols which need topological information to set up a path between the nodes, (ii) protocols which require some geographical information for the route discovery process. Among these routing protocols two distinct categories can be defined:

1) Proactive like DSDV (Destination-Sequenced-Distance Vector) and OLSR (Optimized Link State Routing).

2) Reactive called also 'on-demand' like AODV (Ad-hoc On-demand Distance Vector), and DSR (Dynamic Source Routing). [4].

Short descriptions for the forth protocols listed preview are given below.

DSDV, adapted for self-configuring networks. Every node maintains its own routing table with the information about the cost of the links and network topology between the nodes.

OLSR, it uses shortest-path algorithm having the access to the routing information storing and updating periodically whenever it is needed.

AODV, it uses RREQ/RREP (Route Request/ Route Reply) mechanism for route discovery and destination SN (Sequence Numbers) for each route entry like DSDV.

DSR, it is based on RREQ/RREP packets. Like AODV protocol. However, RREQ maintains information about the whole path from the source to the destination node and gathers the addresses of the 'visited' nodes, not just the next hop. Moreover, the information is stored in a route cache instead of the routing table by every node. [4]

3. IEEE 802.11E ORIGINAL STANDARD MAC FUNCTIONS

3.1. Enhanced Distributed Channel Access and Coordination Function

The main concern of the research group, in the case of IEEE 802.11e, is to improve QoS requirements without sacrificing the interests of industry players concerned. The mechanism of distributed access, namely EDCA allows differentiation of services established at the MAC layer.
In the IEEE 802.11 (DCF), as queries are short, each occupying the network shortly, and waiting times remain still be low, the problem does not arise. However, things get complicated when transferring large files such as video or voice. To remedy these shortcomings, a new 802.11 integrating QoS, the IEEE 802.11e (EDCA), has been proposed.

The standard IEEE 802.11e aims to provide opportunities for QoS at the data link layer. It also defines the needs of different packages in terms of bandwidth and delay to allow better transmission of voice and video. IEEE 802.11e add extensions to enhance the QoS for applications with specific quality requirements, with preserving backward compatibility with variants of existing wireless networks.

The EDCA is an improvement of traditional communication mode DCF of IEEE 802.11. This protocol introduces a new concept of access category or AC (Access Category). Categories of access are: "Background", "Best Effort", video and voice. EDCA provides differentiated access and distributed to the media as well. This protocol assigns each traffic class access containing well-defined values for the parameters of DCF access. Access Media for a station depends upon the type of access associated with the stream to be transmitted. [5], [6].

The EDCA is designed for the contention-based prioritized QoS support. Table 1 show that in EDCA, each QoS-enhanced STA (QSTA) has 4 queues (ACs), to support 8 user priorities (UPs) [5] which are further mapped into four ACs

In the end, the mechanism of differentiation EDCA can provide opportunities in terms of QoS. Introduced changes at the MAC layer provide a specific treatment for each type of traffic. Research and simulations show that this differentiation ensures better transmission voice and video. However, some problems remain, such as the degradation of low priority traffic and the lack of differentiation between a call and a new call is ("handoff") [6]

TABLE 1. Access priority on different traffic in 802.11s

Priority	Access Category	Designation
1	0	Background
2	0	Background
0	0	Best Effort
3	1	Video Probing
4	2	Video at 1.5 Mbps
5	2	Video at 1.5 Mbps
6	3	Voice at 64 Kbps
7	3	Voice at 64 Kbps

3.2. Hybrid Coordination Function Controlled Channel Access

HCCA is designed for the parameterized quality of service support, which combines the advantages of DCF and PCF.

HCCA is generally considered the most advanced (and complex) coordination function. With the HCCA, QoS can be configured with great precision. QoS-enabled stations have the ability to request specific transmission parameters (data rate, jitter, etc.) which should allow advanced applications like VoIP and video streaming to work more effectively on 802.11 networks.

HCCA support is not mandatory for 802.11e APs. In fact, few (if any) APs currently available are enabled for HCCA. Implementing the HCCA on end stations uses the existing DCF mechanism for channel access (no change to DCF or EDCA operation is needed). Stations only need to be able to respond to poll messages. On the AP side, a scheduler and queuing mechanism is needed [5], [6].

4. RELATED WORK

Factors in the quality of service routing protocols become very mandatory in wireless networks because the increasing in technological advancement in these area. Getting and managing QoS in WMNs such as delay, bandwidth, paquets loss and rate error is very difficult because of the resource limitations and the complexity associated with the mobility of Mesh users and should be available and manageable

We divide our related work into two parts; the first part is summarizing the solutions into network layer and the second part we summarize a solutions and approaches in liaison layer. Finally we summarize the mains idea of each solution in a global table.

In order to provide QoS in the WMNs network the following models have been proposed:

In the beginning of the WMNs researchers started to analyze the existing routing protocols.

In [4], the principal idea is divided into two parts: first, authors compared four protocols uses in WMNs: AODV, DSR, DSDV and OLSR, with a fixed topology and other mobile, using NS -2. The results confirm that AODV protocol is the best protocol in terms of throughput, delay and that the DSR is the worst among the mentioned protocols.

Secondly, the authors introduced UDP and TCP in same scenarios of the first comparison, to assess the degree of impact of the transport layer at the network layer. The results show that UDP is more interesting than TCP in terms of quality of service management.

We can conclude that there is no ideal or best routing protocols in WMN. From the protocols studied in this paper, AODV and OLSR should be considered as the ideas worth considering. However, scalability is one of the crucial problems also in this case. One of the solutions is to propose a new routing metric for the existing protocols, use hybrid routing techniques or/and multiple radios and interfaces in order to improve performance of the network and provide better capacity of the network

With existing literature and after our previous analysis, the protocol AODV is most advantageous to ensure QoS, with this point; many works were directed towards the extension of AODV, to improve its performances. It is the aim idea of [6]. R-AODV (Rate aware routing protocol based on AODV), use minimum network layer transmission time as a performance metric. Nodes will select higher data rate link using extension of AODV.

The simulation result indicates that extension of AODV protocol can improve the throughput and decrease network delay.

For specific application like, search and rescue or emergency operations in case of natural disaster, policing and fire fighting military applications such as on the battle field, stadium, meeting rooms etc, almost all proposed routing protocols, try to converge into shortest path routing. We know that one of the advantages to use shortest path routing is that it is good for average delay in network and in overall energy efficiency because energy needed to transmit a packet is directly proportional to path length or number of hops. But a weakness of the shortest path routing is restricted to use the same nodes to route the data packets, thus causing some of the nodes to die earlier resulting into holes in the network and some of the heavily loaded nodes or even worst into partitioning of the network. Thus the need for load balanced routing emerges.

In [7] authors formulate the problem of routing as a network optimization problem, and present a general linear programming (LP) formulation for modelling the problem. Kumar and al proposes the optimized algorithm for known traffic demand and then explain the performance ratio for this. The routing algorithms derived from these formulations usually claim analytical properties such as optimal resource utilization and throughput fairness. The simulation results demonstrate that their statistical problem formulation could effectively incorporate the traffic demand uncertainty in routing optimization, and its algorithm outperforms the algorithm which only considers the static traffic demand. To achieve this objective the problem for congestion has been designed.

Overhead and bandwidth parameters are very important to have a robust network, En efficient routing protocol can solve theses problem; in next paragraphs we will summarize the recent proposed algorithm.

In [8] the global idea is to establish a route from the source to the destination that allows traffic flow within a guaranteed end-to-end latency using the minimum control overhead. Solution minimizes control overhead by effectively controlling broadcast messages in the network and it based on a reliable estimation of wireless link quality and the available bandwidth on a path routing. The quality of service awareness in the protocol is achieved by a robust estimation of the available bandwidth of the wireless channel and a proactive discovery of the routing path by an accurate estimation of the wireless link quality. Finally, the protocol uses the multi-point relay (MPR) nodes to minimize the overhead due to flooding.

In the opposite direction, from mesh nodes to Internet nodes, for all mesh nodes it exist only one direction so the gateways needs to be maintained. However, on the backward path from the Internet to mesh nodes, an individual route for every mesh node is required.

Liu et al [9] investigate protocols for this case of routing in wireless mesh networks. Using simulation experiments with realistic mobility patterns of pedestrians and cars in cities, they compare three protocols AODV, FBR and GSR, each of them represents a family of routing protocol: (i) AODV a reactive routing protocol, with an extension for mesh networks, (ii) FBR, a proactive protocol, and (iii) GSR, a source routing protocol. Their results demonstrate and confirm that an extended AODV seems to be neither scalable nor does it achieve a high packet delivery ratio; FBR has the highest packet delivery ratio but is not scalable to the network size. A good compromise is provided by GSR, which is the most scalable.

Another vision to create a solution to guarantee the bandwidth in wireless mesh network is proposed by Liu et al [10], authors proposed a QoS backup route mechanism to accommodate multimedia traffic flows in mobile WMNs and an available bandwidth estimation algorithm plus Moreover, to validate the correctness of them proposed algorithm, Liu et al implemented their algorithm on the campus wireless mesh network testbed. Their experiments and implementation show that their mechanisms can improve the network stability, throughput, and delivery ratio effectively, while decreasing the number of route failure. They implement their proposed algorithms on the testbed through an improved DSR protocol. Their implementation and experiments show that the mechanisms can effectively improve the network stability, throughput, delivery ratio, while decreasing the route invalidation ratio, and can guarantee the fluent transmission of multimedia streams.

In order to support multimedia transmission with QoS requirements, they improve the wireless routing protocol on the testbed with a dynamic ACK mechanism, which is used to balance the throughput and the quality of transmission. Additionally, authors introduce a dynamic mechanism to change the multimedia coding rate dynamically at the source node according to the available bandwidth. Moreover, they also made improvement on the admission control protocol to facilitate an experiment.

The first assertion that we can do, is that, according to the comparative studies results, done to determine what is the best choice between the existing routing algorithms in the state of the art, AODV and OLSR are the best choice by report to others, in terms of QOS.

The second assertion is that several trends have emerged, as follows:

- Extending the traditional routing algorithms such as AODV, DSR, and OLSR, to improve their performances.
- Changing values of the metric, like hybrid or dynamic metric, as bandwidth of links, or end-to-end latency instead of number of hops, for example.
- Propose protocols completely different from those present in the802.11s standard.
- Use of the clustering approach

The mesh network, as is a special case of Ad-hoc networks and MANET networks. These include a new vision of routing protocols based clusters, whose principle is very simple: divide the whole network into several parts, each party will elect a central node, responsible for coordination of routing information between other adjacent nodes, that node is named CH (Cluster Head), other nodes called its members. Communication in this type of network is simple, any member wishing to transmit, do it through its CH. The latter has a routing table, if the destination is internal (in the same group), then the delivery will be direct, if not the CH sends queries to neighbors to find the right path.

Very recent works have focused on this type of MANET routing. Mukesh Kumar [11] compared a routing protocol named CBRP (Cluster Based Routing Protocol) which gave results much interest as the basic protocols in terms of QoS (delay, throughput) and a good transition to across the MANET.

MAC protocol design is important in meeting QoS requirements since much of the latency experienced in a wireless network occurs in accessing the shared medium. In addition, MAC protocols must be interoperable with existing wireless networks operating on the same RF spectrum and fair toward all users.

Abundant hidden node collisions and correlated channel access due to multi-hop flows degrade QoS in wireless mesh networks. QoS in nearby WLANs operating on a single channel is also affected.

Mathilde Benveniste [13] propose using wider contention windows for backoff to lower the risk of repeated hidden-node collisions, a spatial extension of the TXOP concept called 'express forwarding' is an enhancement of the CSMA/CA protocol designed to reduce the latency experienced end-to-end by a multi-hop wireless mesh to clear multi-hop flows sooner, and a new mechanism called 'express retransmission' to reduce collisions on retransmission.

Simulation results show the potential benefit of the proposed enhancements and impact on fairness.

A key approach to increasing network capacity is to equip wireless routers with smart antennas. These routers, therefore, are capable of focusing their transmission on specific neighbors whilst causing little interference to other nodes. This, however, assumes there is a link scheduling algorithm that activates links in a way that maximizes network capacity. To this end, Chin et al. [14] propose a novel link activation algorithm that maximally creates a bipartite graph, which is then used to derive the link activation schedule of each router.

Authors verified the proposed algorithm on various topologies with increasing node degrees as well as node numbers. From extensive simulation studies, authors find that their algorithm outperforms existing algorithms in terms of the number of links activated per slot, super frame length, computation time, route length and end-to-end delay.

Navda et al. [15] design and evaluate Ganges, a wireless mesh network architecture that can efficiently transport real time video streams from multiple sources to a central monitoring station. Video quality suffers from deterioration in the presence of bursty network losses and due to packets missing their playback /deadline. Ganges spatially separates the paths to reduce inter-flow contention. It finds out a fair rate allocation for the different video sources.
The wireless routers in the mesh network implement several optimizations in order to reduce the end-to-end delay variation. Ganges improves the network capacity by a shortest path tree, and video picture quality by Central.

The contribution of this work [16] is twofold. First Riggio et al. propose a methodology for evaluating multimedia applications over real world WMN deployments.

Second, based on the defined methodology, they report the results of an extensive measurement campaign performed exploiting an IEEE 802.11-based WMN testbed deployed in a typical office environment. The focus of their research on three mainstream multimedia applications: VoIP, Video Conference, and Video Streaming. Two single-hop star-shaped network topologies (with symmetric and asymmetric links) and a multi-hop string topology have been exploited in order to provide a comprehensive evaluation of the testbed’s performances.

For the transportation of real-time video, Moleme et al. [17] proposes a two-layer mechanism. In their solution, for channel error control ,rate adaptation is implemented in the data link layer, link stability and reliability. In addition, the network layer routing protocol is optimized for congestion control and optimal route selection by using congestion information from the data link layer and link quality metric from the network layer.

The proposed scheme aims at ameliorating the performance of UDP in WMV video streaming applications by improving throughput, packet loss and latency, so the authors in this work try to improve a standard protocol (UDP) to improve the QoS, us you know as we know, affect the operation of a standard protocol is a risk, it may have secondary effects on the proposed solutions

The framework is based on S-TDMA scheduling at the MAC layer, which is periodically executed at the network manager to adapt to changes in traffic demand. While scheduling computation is centralized, admission control is performed locally at the wireless backbone nodes, thus reducing signaling.

Leoncini et al. [18] propose two bandwidth distribution and related admission control policies, which are at opposite ends of the network utilization/spatial fairness tradeoff.

The link layer is very important to provide QoS for Wireless Mesh Networks. Researchers are focused on specific areas as we have seen. A set of researches focus on mechanisms of allocating resources such as CSMA/CA or TDMA. Other studied queue management, by doing a control admission, and another approach is to use correcting codes [19].

TABLE 2. Summarize of different approaches in WMNs

Implementations	**Average delay**	**Over head**	**Packets loss**	**Through - put**	**Comments**
Yinpeng Yu et al. [4]	+	+	+	+	- comparison between basic routing protocols in WMN
Zhang et al. [7]	+	-	-	+	- Improvement of AODV and comparison with the later.
Kumar et al. [8]	-	-	-	+	- Linear solution to solve short path in a critical and real applications
Sen [9]	-	+	-	+	- Establish a route that allows traffic flow within a guaranteed end-to-end latency using the minimum control overhead. - Estimation of wireless link quality and the available bandwidth are used
Baumann et al [10]	-	+	-	+	- The authors investigate protocols for backward path routing in wireless mesh networks.
Liu et al [11]	-	-	-	-	- available bandwidth estimation algorithm plus a QoS backup route mechanism - real application has been tested
Benveniste [13]	+	-	+	-	- using wider contention windows for backoff - author propose an express retransmission to reduce collision
Chin et al [14]	+	-	-	-	- An improvement of TDMA is using in place of CSMA/CA
Navda et al. [15]	-	+	+	+	- Evaluate wireless mesh network architecture that can efficiently transport real time video
Riggio et al. [16]	+	-	+	+	- Methodology for evaluating multimedia applications over real world WMN deployments.
Moleme et al [17]	+	-	-	+	- Optimization of routing protocol and mechanism of channel control
Leoncini et al [18]	-	+	-	+	- Improvement TDMA to adapt to changes in traffic demand

As we say on the beginning of our related work, we summarize all the proposed works on the following table. In this paper, the signs (+ / -) means that the authors included the chosen parameter or not among the parameters simulation in the papers.

5. OUR SYSTEM MODEL

As we say in the end of introduction, in our approaches, we propose an efficient routing protocol Q-CBRP (QoS- Clustering Based Routing Protocol) to transport multimedia traffics in wireless mesh network and we improve MAC layer to support a real time applications on WMN. We must to signal that the routing protocol is one of our approaches in [23]. The goal of this paper is to develop our proposal routing protocol with the improvement of MAC layer and to combine between the two approaches in one and only algorithm.

We will discuss in detail in this paper improvement of MAC layer to support real time applications over WMNs, and to combine between this algorithm and the routing algorithm, we create a new queues in our routing protocol, theses queues are the same in the MAC layer.

In this section, we present the basic idea of the Q-CBRP and its implementation in detail. Section 6.1 introduces the routing process CBRP briefly. In section 6.2 we define the terminology of Q-CBRP. In section 6.3 we describe and discuss about the Comparison between Q-CBRP and another's routing protocols.

After this overview we will explain our approaches in MAC layer, Section 7.1 present the improvement of MAC layer in our approaches, Section 7.2 we propose our scenario and at the last, we show results for our model.

6. OUR USES ROUTING PROTOCOL

6.1. Overview of CBRP

In generally, in sensor and MANET networks, there are several clustering protocols, among them: CBRP (Cluster Based Routing Protocol). Cluster Based Routing Protocol is an on-demand routing protocol, where the nodes are divided into several clusters. It uses clustering's structure for routing protocol.

Divides the network into interconnected substructures is clustering process that called clusters. Each cluster has a cluster head (CH) as coordinator within the substructure. Each CH acts as a temporary base station within its zone or cluster and communicates with other CHs.

CBRP is designed to be used in Wireless sensor network and mobile ad hoc network. The protocol divides the nodes of the Ad-hoc network into a number of overlapping or disjoint two-hop diameter clusters in a distributed manner. Each cluster chooses a head to retain cluster membership information. There are four possible states for the node: Isolated, Normal, Cluster-head (CH) or Gateway. Initially all nodes are in the state of Isolated. Each node maintains the Neighbor table where in the information about the other neighbors nodes is stored; CH have another table where include the information about the other neighbor cluster heads is stored. [20] The protocol efficiently minimizes the flooding traffic during route discovery and speeds up this process as well.

TABLE 3. Cluster Head Table

ID_neighbors_ Clusters	ID_neighbors_ Gateways	ID_members

- ID_membres : ID of all members in the same CH

TABLE 4. Gatway Table

ID_CH	ID_Members

TABLE 5. Members Table

ID_Cluster	Status	Link Status

- Status of neighboring nodes (Cluster-head, gateway or member)
- Link status (uni-directional or bi-directional)

Route discovery is done by using source routing. In the CBRP only cluster heads are flooded with route request package (RREQ). Gateway nodes receive the RREQs as well, but without broadcasting them. They forward them to the next cluster head. This strategy reduces the network traffic.

Initially, node S broadcasts a RREQ with unique ID containing the destination's address, the neighboring cluster head(s) including the gateway nodes to reach them and the cluster address list which consist the addresses of the cluster heads forming the route [21].

6.2. Terminologie for Q-CBRP

In previous works [21-22], the results show that the protocol CBRP improves QoS in mobile ad-hoc network in general. We didn't stop in this idea; so we study in detail the basic protocol to make improvements to ensure QoS in our Mesh Network.

Our improvements are summarized in two points. First we improve packet header of basic CBRP with more information to have a more complete protocol and the second point we add some fields in routing tables that we will explain in the next.

Packet ID	Source Address	Dest_ Address	List_of_visited _node	TTL	R (bps)

Figure 2. Data packet header

Figure 2 describe our proposal Data Packet Header (DPH), different to DPH in CBRP, where we add two fields in the DPH of original CBRP, the TTL (Time To Live), contains a count of number of intermediate nodes traversed to avoid the packets loop and management of the available bandwidth to guarantee QoS (R) it signifies the minimum bandwidth required by a Mesh client to transmit the data.

In our algorithm (Q-CBRP): Cluster Head Table is the same tables in CBRP protocol (Table 3) but an improvement are added in the Gateway Table (Table 4).

Gateway Table maintains the information regarding the gateway node and the available bandwidth over those nodes. We add in Gateway Table an Available Bandwidth, that mean when the data packet is sent to the destination or intermediate node it will reserve the bandwidth required by it. To perform this function of managing bandwidth, admission control mechanism is added where we also block flows when there is not enough bandwidth to avoid packets loss [23].

TABLE 6. Gateway Table in Q-CBRP

ID_CH	ID_Members	Available Bandwidth

In Q-CBRP, the Member Table maintains the information about its neighboring nodes by broadcasting a Beacon Request Packet.

6.3. QoS- Cluster Based Routing Protocol for WMN

Each node in wireless network maintains a table called Member table (Table 5) containing the address of Neighboring nodes. This table is maintained in the decreasing order of their distance from this particular node. Each node also stores the address of the Cluster-head. Cluster-head also maintains member table as well as it also maintains a gateway table which stores the address of gateway nodes in the decreasing order of distance from the centre head node. This Gateway table stores address as well as the available bandwidth of the gateway nodes.

Whenever a source node, that is member node, generates a request to transfer the data to a CH node, CH check the destination node address in it member table. If the matching node is found in the member table, packet is transferred to that node. If no match is found, then the data packet will be sent to the neighbor cluster-head. CH will again check for the match in its member table. If no match is found, cluster-head will check for the node in the Gateway node table at which the required bandwidth is available. The data packet is sent to the node at which the required bandwidth is available. The node address will be copied to List_of_Visited_Nodes field of data packet header. This field will help in the prevention of loops. Using this field, same data packet will not be sent to a particular node more than once. Reduce the available bandwidth of the gateway node. This process will continue till the destination node is reached or if the count of visited nodes get increased than the count in TTL (Time to live) field. If this count becomes more than TTL the data packet is dropped and a message is sent to source node. And finally to ensure that the packets are received in the destination and when the nodes haven't bandwidth desired by the Source, the node stop traffic for a few minutes for complete a management of the queue to avoid packet loss [23].

6.4. Discussions

The proposed protocol [23] has been implemented in the network simulator ns-2 version 2.34 [24]. The IEEE 802.11 DCF (Distributed Coordinated Function) MAC was used as the basic for the experiments with a channel capacity of 2Mb/sec.

The transmission range of each node was set to 250m. CBR is the traffic sources. The number of nodes changed with 3 values (20, 40 and 60).

In our proposed model, we chose a topology where there exist fixed nodes that represent Mesh Routers (MR) theses nodes can be CH or Gateway and mobile nodes that have a randomly circulating, theses node representing Mesh Clients MC.

Three metrics evaluated our network performances, theses metrics are: Packet Delivery Ratio (PDR), Average End to End delay (Delay) and routing Overhead (Overhead).

In [23] AODV,CBRP and Q-CBRP protocols were compared in terms of Packet delivery ratio, Average delay and routing overhead when subjected to change in pause time and varying number of Mesh clients. The results showed that by comparing the performance between Q-CBRP, CBRP and AODV, we can conclude that cluster topologies bring scalability and routing efficiency for a WMN as network size increase. By adding the management of bandwidth to our own algorithm with admission control, and add some filed in Data header plus some modification on routing Table, the mesh network is able to transport multimedia streams by offering a wider and more stable throughput compared to the basic protocol (CBRP).

7. OUR USES MAC LAYER

IEEE802.11e uses four queues with eight different priorities as mentioned previously in Table 1. For us, theses queues will not be efficient for some organizations which utilize most of their wireless networks for VoIP and video conferencing applications. According to IEEE 802.11e, two queues will be used for background and best effort data with three different priorities. Otherwise, if we consider a scenario where twenty stations are transmitting VoIP and video with one station transmitting best effort data, it will not be efficient to use two queues with three different priorities for the best effort station. In the next sections, we propose our ns-2 simulation which will overcome the mentioned limitations of the original standard when uses for VoIP and video applications.

7.1. Our Improvements

In our case, we change simulations parameters in standard IEEE 802.11e, The TOXP limit parameter is ignored in the implementation of the real network, and in our case we will demonstrate its importance

- In our approach, we used three flows (Video, VoIP and Best effort); each flow had a different data priority, we increase data priority of voice and video and we will compare with best effort data.
- We change some of the simulation parameters such as CWmin, CWmax, and AIFSN in the original IEEE802.11e standard.
- TXOP limit change varies with the priority of data.

7.2. Simulation

In our simulation, we have considered three queues to maximize the utilization of the VoIP and video applications in the network. We have also changed some of the simulation parameters such as CWmin, CWmax, and AIFSN in the original IEEE802.11e standard [24].

TABLE 7. IEEE 802.11e MAC Parameters

Parameter	**Value**
Slot time	20 us
Beacon interval	100 ms
Fragmentation threshold	1024 Bytes
RTS threshold	500Bytes
SIFS	20 us
PIFS	40 us
DIFS	60 us
MSDU (Voice and Video)	60 ms
MSDU (data)	200 ms
Retry limit	7
TXOP limit	3000 us

Our scenario includes a single cluster head with variable number of mobile stations moving randomly within its coverage area. The number of mobile stations is increased form 3 to 15 with three stations at a time. Every three QoS stations transmit three different types of flows (video, VoIP and best effort data) to the same destination (CH). We choose IEEE 802.11b PHY layer and Q-CBRP for routing protocol.

TABLE 8. Simulation parameters of our scenario.

Simulation parameter	Voice	Video	Best effort
Transport protocol	UDP	UDP	UDP
CWmin	3	7	15
CWmax	7	15	1023
AIFSN	2	2	3
Packet size (bytes)	160	1280	1500
Packet interval (ms)	20	10	12.5
Data rate (kbps)	64	1024	960
TXOP limit (us)	3500	3000	2500

Three metrics are evaluated in our network performances, theses metrics are: Throughput, Average Delay and ratio of packets loss.

We start with the throughput results for the first scenario, which is shown in Figures 3 and 4. In Figure3, the graph illustrates the effect of increasing the number of active QoS stations transmitting data to the access point on the throughput values for the three data flows. The sending rate in this simulation is 11 Mbps, while the CWmin and CWmax size and AIFSN values as stated in Table 8.

TABLE 9. Original IEEE 802.11e simulation parameters.

Simulation parameter	Voice	Video	Best effort
CWmin	7	10	31
CWmax	7	31	1023
AIFSN	1	2	3

In comparison, Figure 4 illustrates the effect of increasing the number of active QoS stations transmitting data to the access point on the throughput values for the three data flows using IEEE 802.11e standard [24] CW size and AIFSN values shown in Table 9.

Our CW size and AIFSN values provide better results considering the voice and video flows, but not the best effort data flow.

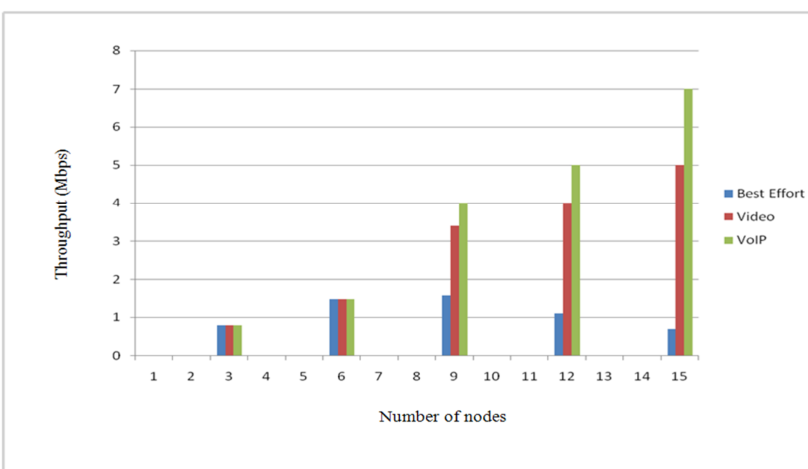

Figure 3. Simulation of Throughput using Q-CBRP with Improvement of MAC layer

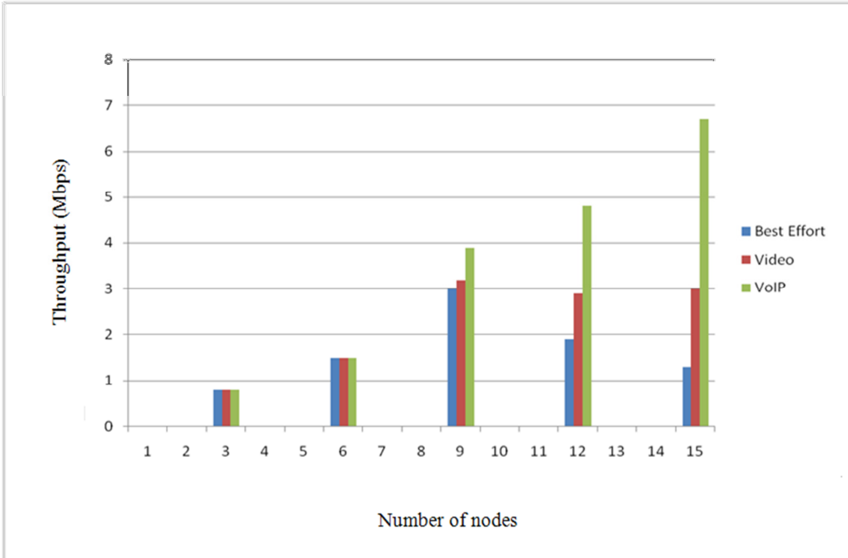

Figure 4. Simulation of Throughput using Q-CBRP with standard MAC layer

This is clearly observed from Figures 3 and 4. In both cases, it is clearly seen from the graphs that IEEE 802.11e provides service differentiation for different priorities when the system is heavily loaded by increasing the number of stations. When the number of stations is 3 or 6, all the data flows have equal channel capacity. However, in the case of 9, 12 and 15 stations, the channel is reserved for higher priority data flows. As we mentioned in the previous sections, voice flow has the highest priority among the others, while the best effort data flow has the lowest priority.

Another important factor that has a great effect on the IEEE 802.11e WLAN performance for QoS support is the packet drop and loss ratio. To calculate the number of packets dropped or lost in the transmission medium, we subtract the number of packet successfully received by the receiver (the cluster Head in our case) from the total number of packets sent by the sender (mobile stations). Table 10 shows the effect of increasing the number of active QoS stations on the packet drop and loss ratio. We vary the network load by 3 stations at a time sending three different data flows. In this simulation, we maintained the same simulation parameters in Table 8.

TABLE 10. Packet Drop ratio vs number of nodes

Number of stations	Best Effort	Video	voice
3	0 %	0 %	0 %
6	6.51 %	1.11 %	0 %
9	13.45 %	4.82 %	1.97 %
12	58.51 %	15.28 %	8.34 %
15	75.76 %	39.52 %	15.73 %

It is clearly observed from Table 10, the service differentiation between the different data flows according to their priority levels. This difference appears more when the channel is heavily loaded by increasing the number of stations. For the best effort data flow, the packet drop starts when the number of stations is 3. That is due to the fact that best effort data flow has the lowest priority. On the other hand, as the voice flow is considered, the packet drop starts when the number of stations increases to 9. This reflects the fact that voice flow has the highest priority to reserve the channel when it is heavily loaded. The percentage of the packet drop for reaches up to 76 % for the maximum channel load considering the best effort data flow, while it reaches up to 16 % for the voice flow. In fact, the system throughput is inversely proportional to the number of dropped and lost packets. In addition, packet drop has great effect on the network average end-to-end delay. Relatively, delay is directly proportional to the number of dropped packets.

The last parameter of our simulation is the average delay, delay is another important performance metric that should be taken into account. Figures 5 and 6 represent the results obtained from our simulation using different CW size and AIFSN values.

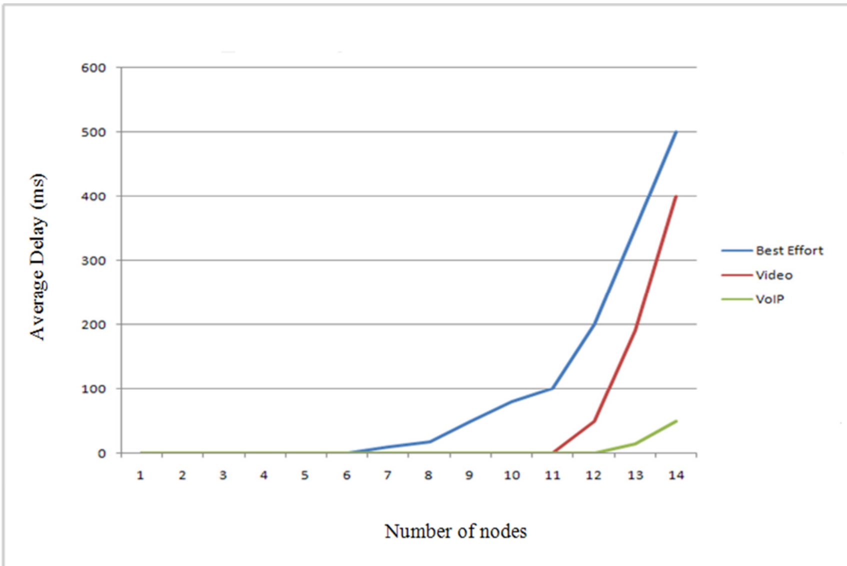

Figure 5. Simulation of Average Delay using Q-CBRP with standard MAC layer

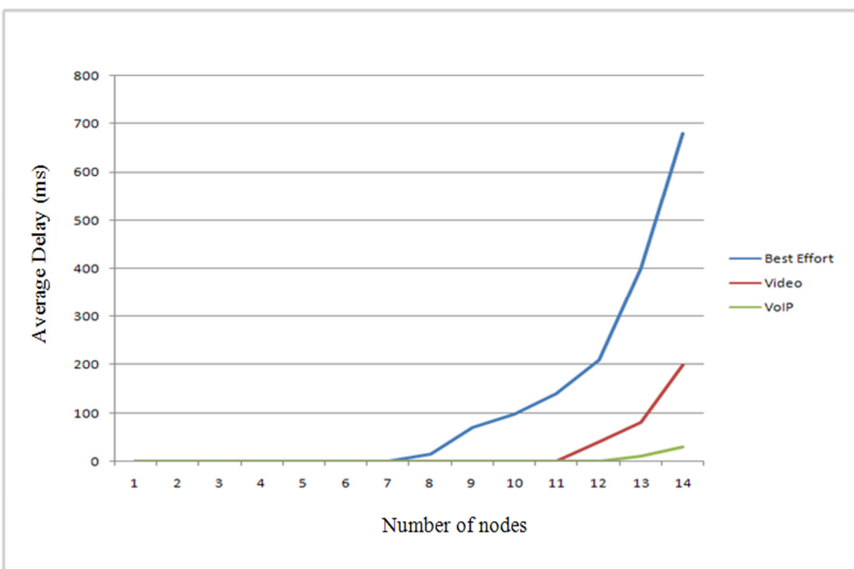

Figure 6. Simulation of Average Delay using Q-CBRP with Improvement of MAC layer

The graphs in Figures 5 and 6 illustrate the effect of increasing the number of active QoS stations transmitting data to the access point on the average end-to-end delay values for the three data flows separately from source (mobile stations) to destination CH. Our proposed CW size and AIFSN values enhances the performance with respect to the voice and video flows, but not for the best effort data flow. This is shown in Figure 6 when we have more than 12 active QoS stations. On the other hand, Figure 6 represents the simulation result using the CW size and AIFSN values in Table 8. However, as shown in this Figure 5, these values provide better results than ours with respect to best effort data flow. This is accepted for our idea, because our main concern is to enhance the performance for multimedia data flows such as voice and video.

8. CONCLUSION

We divide our paper in two proposal approach, the first approach is to use an efficient routing protocol to support multimedia application in WMNs, but for us, only efficient routing protocol in not sufficient to support a real time applications in WMNs! so we keep our routing protocol and we improve in MAC layer to had better results.

This paper compared the performance of our Algorithm Q-CBRP with improvement MAC layer in WMN and the same routing protocol with standard MAC layer. These two aspects were compared in terms of Packet loss, Average delay and Throughput.

The results show that our proposal algorithm is better in term QoS to compare with standard parameters. So we can conclude that if we combine two approaches in two level of OSI model, we have better results to compare with an approach that used only one level in OSI model.

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